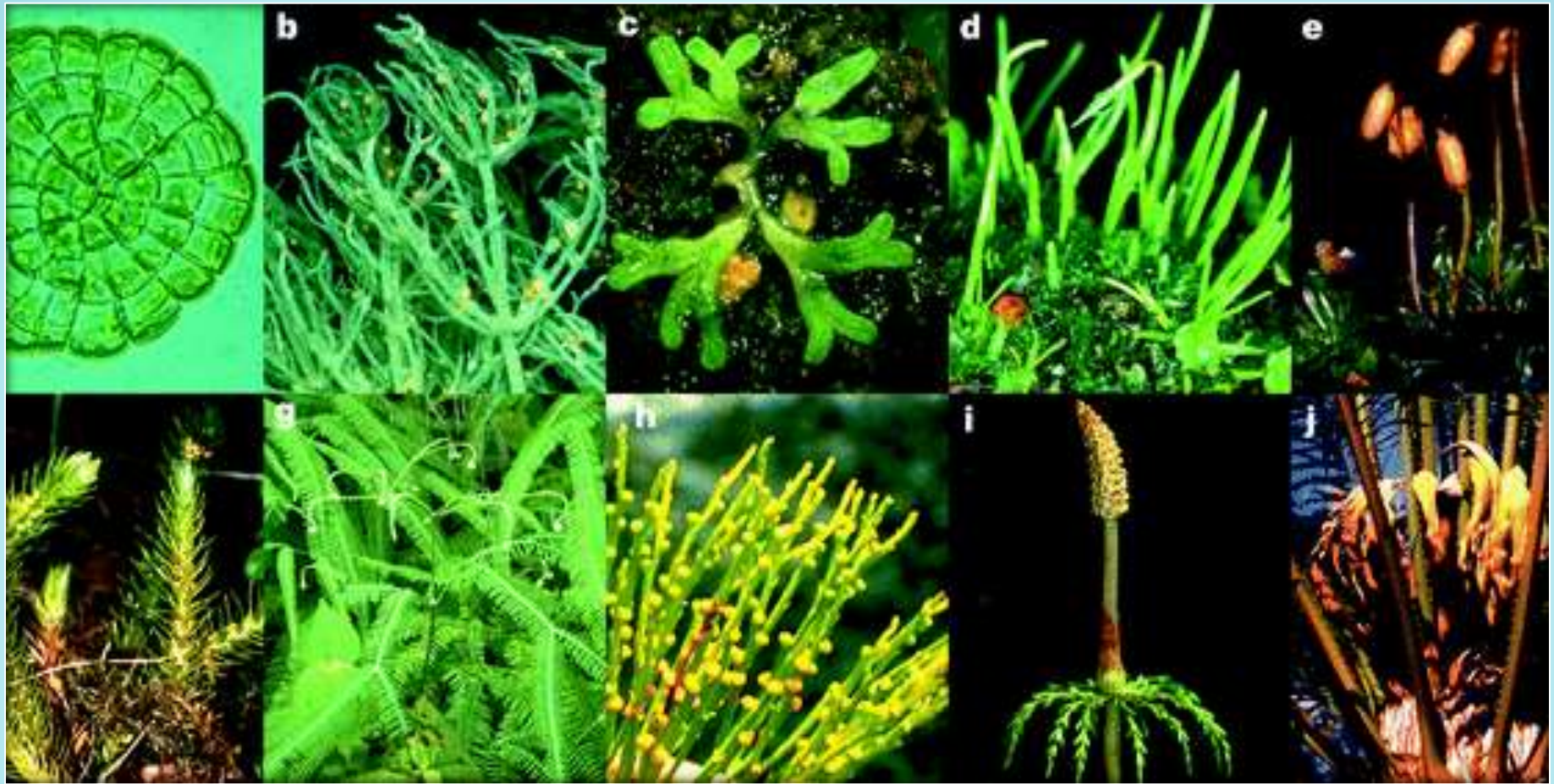




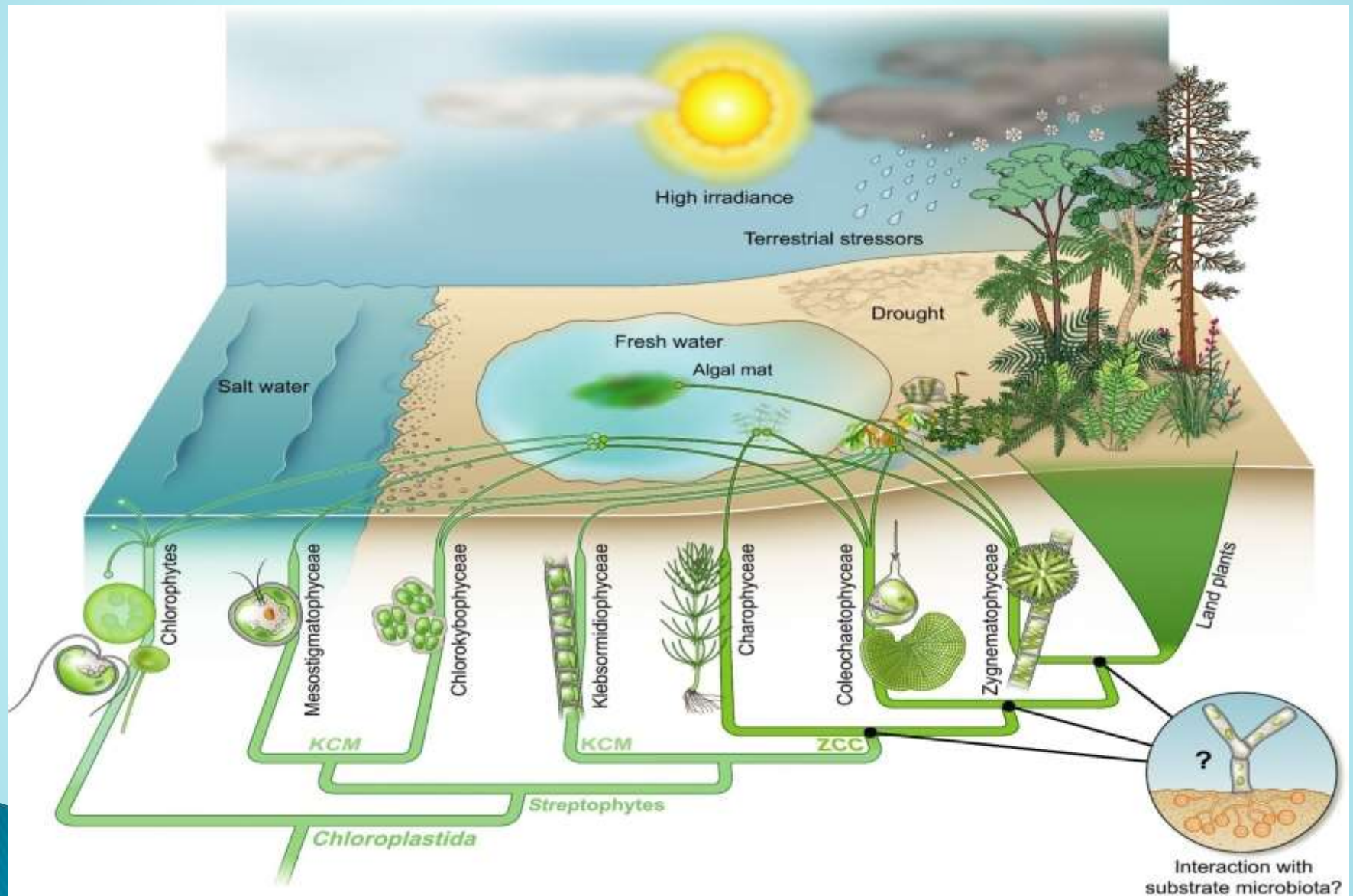
## ORIGIN & EVOLUTION OF ANGIOSPERMS >>

### A BIRD'S EYE VIEW

**A PRESENTATION BY**

**Dr. N. Sannigrahi, Associate Professor,  
Department of Botany,  
Nistarini College, Purulia,  
D.B. Road, Purulia (W.B) India, 723101  
nandadulal2002prl@gmail.com**

# EVOLUTION OF PLANTS



# ANGIOSPERMS

- ▶ Angiosperms or flowering plants form the largest group of plant kingdom, including about 300 families (411 families, Hutchinson), 8,000 genera and 300,000 species. They are considered to be highest evolved plants on the surface of the earth. From Cretaceous age, the angiosperms eclipsed all other vegetation and now they are dominant. They are found almost everywhere in each possible type of habitat and climate. They occur in deep lakes, deserts, in beds of seas and even on high peaks of mountains. The species of *Opuntia* (Cactaceae) can survive without water in acute desert conditions, whereas on the other hand the species of *Hydrilla* (aquatic plant) are extremely sensitive to drought conditions. Some species are found on rocks, some in waterfalls and also some are marine. The species of *Rhizophora*, popularly known as 'mangrove vegetation' are found near the water of the sea. The epiphytes, parasites, saprophytes, symbionts and even insectivorous plants are also not uncommon. They may be annual, biennial or perennial herbs, shrubs, trees, climbers, twiners and lianas. On one hand the angiosperms may be as minute in size as a pin head, e.g., *Wolffia microscopica*, on the other extremity like *Eucalyptus* of Australia may reach up to 300 feet in height.

## CHARACTERS OF ANGIOSPERMS

- i. The sporophyte which is the dominant plant in the life-cycle is differentiated into roots, stem and leaves.
- ii. The highest degree of perfection of the vascular system with true vessels in the xylem and companion cells in the phloem.
- iii. The organization of the microsporophyll's (stamens) and megasporophylls (carpel) into a structure called the flower, which is typical only of the angiosperms.
- iv. The presence of four microsporangia (pollen sacs) per microsporophyll. The ovules are always enclosed in an ovary which is the basal region of the megasporophyll.
- v. Production of two kinds of spores, microspores (pollen grains) and megaspores. Angiosperms thus are heterosporous.
- vi. Presence of single functional megaspore which is permanently retained within the nucellus or mega-sporangium.
- vii. Adaptation of flower to insect pollination.
- viii. Pollination consists in the transference of pollen grains from anther to stigma.

# CHARACTERS OF ANGIOSPERMS

- X. Extreme reduction in size, duration of existence and complexity of the structure of the gametophytes which are entirely parasitic.
- XI. The male gametophyte has reached the limits of reduction. It consists only of the pollen grain and the pollen tube contains the tube nucleus and two male gametes or nuclei. The male cells (gametes) are non-ciliated.
- XII. The female gametophyte lacks any extensive development of vegetative tissue. It consists of three egg apparatus cells, three antipodal cells and two polar nuclei in the centre of the embryo sac.
- XII. The non-motile male cells or nuclei are carried bodily to the neighborhood of egg apparatus by the pollen tube.
- XIV. The seed or seeds remain enclosed in the ripened ovary called the fruit.
- XV. The phenomenon of double fertilization or triple fusion is the characteristic of the angiosperms.
- XVI. The endosperm develops after fertilization. It is triploid.
- XVII. The angiosperms are completely adapted to life on land.
- XVIII. Spore dimorphisim having resulted in the production of gametophytes, male and female

# ORIGIN OF ANGIOSPERMS

- ▶ The angiosperms appeared suddenly in Cretaceous age about 65 million years back. Charles Darwin described this sudden appearance of angiosperms in lower or upper Cretaceous as an ‘abominable mystery. When angiosperms appeared for the first time in lower or upper Cretaceous, they were full fledged like the trees and the herbs of today. In support of this view Prof. Knowlton advocates in his ‘Plant of the past’, **“from the time of their appearance they did not progress at all due to their full-fledged appearance in the Cretaceous”**.
- ▶ The fossil records of the angiosperms also support their appearance full-fledged in lower or upper Cretaceous. The fossils of that age are so characteristic and modern in appearance that most of them can be referred unmistakably to living families, genera and even to some species.
- ▶ The forms of cycads and conifers, which long dominated the universe were already pushed back and the earth had become infact the earth of flowering plants. Charles Darwin has called this sudden appearance of angiosperms as an “abominable mystery”.

# CHARACTERS OF ANGIOSPERMS

- ▶ However, some workers do not agree with the doctrine of ‘abominable mystery’. According to H.H. Thomas (1936), the angiosperms of the past replaced many of older gymnosperms in estuarine and marshy waters. Graud Eury (1906) believes that the angiosperms came into existence through mutation. Guppy (1919) however, supported the view of mutation.
- ▶ Prof. Bertrand is of opinion that all the great groups of vascular plants (Pteridophyta, Gymnosperm and Angiosperms) not only arose quite independently of each other but also they originated simultaneously as far back in the Archian period (2000 million years old-oldest)
- ▶ **These possibilities are:**
  - ▶ 1. That the angiosperms are monophyletic in their origin but have had a very much longer history than at present known, perhaps stretching back into Paleozoic times and with a whole series of missing links;
  - ▶ 2. That the angiosperms are monophyletic but that the first and at present unknown group diverged quickly in terms of geological time, into a considerable number of different groups;
  - ▶ 3. That the angiosperms are polyphyletic.

# HOMOLOGY & ANALOGY

- ▶ **HOMOLOGY** is the resemblance between two organisms due to inheritance from a common ancestry. • Characters with same origin, but, different in appearance or function • The resemblances due to homology are real. • Homology between two organisms can result only from their having evolved from a common ancestor, and the ancestor must also contain the same feature or features for which the two organisms are homologous. Through divergent evolution, organisms may develop homologous structures.
- ▶ **ANALOGY** • Analogy is the resemblance between two organisms due to functional similarity and not due to inheritance from a common ancestry. • Characters with different origin, but, similar in appearance. • The resemblances due to analogy are generally superficial. • Analogy between two organisms can be due to superficial resemblance, i.e., occurrence of a part or an organ in one organism which has the same function as another part or organ in a different organisms.

## HOMOLOGY & ANALOGY

- ▶ Darwin(1959) defined homology as that relationship between which results from their development from the corresponding embryonic parts but Simpson (1961) stated that the homology is the resemblance due to inheritance from a common ancestry and analogy is the resemblance from functional aspect but not due to inheritance from a common ancestry. Wilen (1981) stated that the homology may arise between two characters, two characters states or between two organisms for a particular character state. Two characters are homologous if one is directly derived from the other. These series of characters in question are called morphoclines or phenoclines. The original pre-existing character is called as plesiomorphic and the derived one as apomorphic . The two terms apomorphic and plesiomorphic may be relative.

# PARALLELISM & CONVERGENCE

- ▶ In 'Parallelism', the organisms have a common ancestor but the character-state was not present in their common ancestor while in convergence, two different characters in different ancestors evolving identical character –states. According to Simpson (1961) parallelism is defined as the independent occurrence of similar changes in groups with a common ancestry. In *Ranunculus* two species *R. tripartitus* and *R. hederacea* have similar characters of aquatic habit and dissect leaves which happen due to parallel evolution. In case of Gymnosperms and Dicotyledons with related vessels, there is parallelism.
- ▶ While convergence, similarity is observed between the two distinct phyletic lines with regard to individual organ or to the whole individual. Similar features arise separately in two or more genetically diverse and not related taxa or lineages, In case of Orchidaceae & Asclepiadaceae, pollinia is found and it shows divergence.

# MONOPHYLY, PARAPHYLY, POLYPHYLY & CLADES

- ▶ In general, monophyly refers to derivation from a single ancestor whereas polyphyly refers to derivation from more than one ancestor. In paraphyly, all descendents of the most recent common ancestors are kept in the group.
- ▶ Simpson(1961) defined monophyly as the deviation of a taxon through one or more lineages or descendents from the immediately ancestral taxon of the same or the lower rank. Let one example-say genus B has been derived from the genus A through a single species . The genus is monophyletic at the genus as well as species level. It evolved from the two species of A it shows monophyletic origin at genus level but polyphyletic at the lower rank that is at the species level.
- ▶ There are two different levels of monophyly-a minimum monophyly and strict monophyly. In case of former one, one supraspecific taxon is derived from an equal rank but in case of latter, higher taxon is derived from a single evolutionary species.

# MONOPHYLY, PARAPHYLY, POLYPHYLY & CLADES

- ▶ Henning defined monophyletic group as a group of species descended from a single species and which included all the descendents from this species. In a simpler way, all descendents of a species at a time are placed in a monophyletic group. Two types of monophyletic groups have been demarcated- holophyletic & paraphyletic. In holophyletic, all the descendents of the most common ancestor remain in the group. In paraphyletic, all descendents of the most recent common ancestor are not included in the group. In other words, a paraphyletic taxon is one that includes the most common ancestor, but not all the descendents. A paraphyletic is defined as one that does not include the common ancestor of the members of the taxon. Now, the holophyletic and monophyletic are synonymous.

# CLADOGRAM, DENDROGRAM & EVOLUTIONARY TREE

- ▶ Within a cladograms, a branch that includes a single common ancestor and all of its descendants is called a clade. A cladograms is an evolutionary tree that diagrams the ancestral relationships among organisms. A Group of individuals producing successively, similar and genetically related individuals are called Clades. A clade can be represented by the line diagram is called cladograms which shows woody habit, alternate leaves, cymose inflorescence, 5 red petals, 5 stamens, 2 free carpels and dry fruit with many seeds inside it. A phylogenetic tree depicts phylogenetic tree. The vertical axis shows the geologic period. The branch in the tree represents the origin of the group and the terminal portion indicates the end of the group. The branching emerges from the main axis are the fossil groups which end in the geologic time when the group become extinct.

## **CLADOGRAM, DENDROGRAM & EVOLUTIONARY TREE**

- ▶ Living groups are marked by their distance from the centre. Primitive groups are close to the centre and the advanced groups remain towards the periphery. The branching diagrams are called dendrograms.
- ▶ Wiley (1981) defines phylogenetic tree as a branching diagram portraying hypothesized events linking individual organisms , population or taxa. According to him, it is branching diagram of entities where the branching is based on inferred historical connections between the entities as evidenced by the synapmorphies. It is thus, a phylogenetic or historical dendrogram. Recently all the evolutionary diagrams are drawn are known as evolutionary tree or phyletic tree . These are synonymous with cladograms.

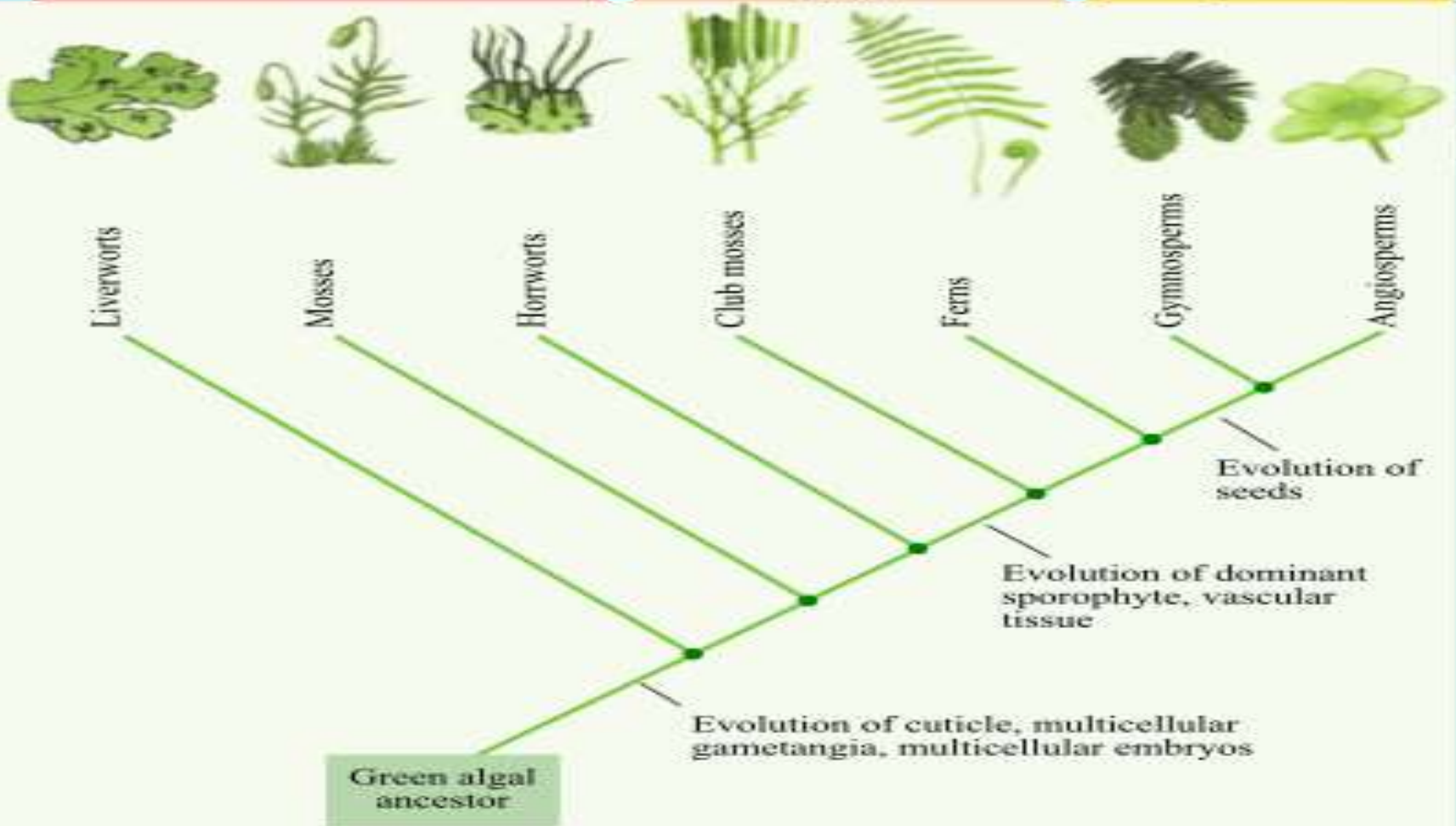
# CLADOGRAM

## Land Plants

Nonvascular bryophytes

Vascular seedless plants

Vascular seed plants



# ORIGIN & EVOLUTION OF ANGIOSPERMS

- ▶ In Biology, evolution is the change in heritable characteristics of biological populations over successive generations. These characteristics are the expressions of genes, which are passed on from parent to offspring during reproduction. Evolution is the most interesting domain of the biology as it induces to explore the magic of the reality of life since the time immemorial along with their changes with the passage of time during the geological period. The most dominant group of the plant kingdom with some unique features induces a number of questions regarding its origin and evolution as the scanty fossil records are enough to come any clear cut distinct conclusion. A form genus, *Clavitopollenites* reported by Couper (1958) from Berremian and Aptian strata belonging to the early Cretaceous of England about 132-112 mY is the most important examples in this regard. Many fossils show the herbaceous nature of angiosperms similar with Magnoliidae, Magnoliales, Laurales etc and the late cretaceous era contains 50% fossils being angiosperm in nature. *Archaeostrobilus cupulanthus* , a form genus has resemblance with *Welwitschia*, a gymnosperm of late Triassic of Texas with spirally arranged macro cupules on constructed male and female spikes.

# ORIGIN & EVOLUTION OF ANGIOSPERMS

- ▶ With the help of several findings, it can be concluded that there are two probable dates regarding the origin of angiosperms.-one in the Triassic
- ▶ when stem angiosperms reported by Doyle and Donoghue in 1993 as 'angiophytes' and the second one refers to crown group of angiosperms of late Jurassic period that splits into extant subgroups.
- ▶ 1. Axelrod(1970) proposed the origin of angiosperm in mild uplands at low latitudes,
- ▶ 2. South east Asia near to Malaysia as the site of the origin by Smith, 1970,
- ▶ 3.According to Stebbins (1974), it has been evolved under environmental stress and drought,
- ▶ 4.Bailey & Takhtajan (1969) studies the flora of Southern Pacific Islands and supplied the missing link as the polyphyletic origin of angiosperms.

# ORIGIN & EVOLUTION OF ANGIOSPERMS

- ▶ Although the origin of angiosperms is an abominable mystery, there are two schools of thoughts- Monophyletic & polyphyletic origin. Hutchinson(1973), Thorne(1983-2007). Takhtajan(1997), Bremer et al. APGII, 2003 and others in favor of the Monophyletic origin of angiosperms and they proposed that monocotyledons have evolved from their primitive dicotyledons and this is based on sieve tubes, companion cells, closed carpels, 8 nucleate embryo sac, reduced gametophytes, triploid endosperm. Sporne (1974) viewed that gymnosperms are the ancestors of angiosperms and independent development of characters took place in the passage of evolution. Melville(1983) argues for the polyphyletic origin and the Glosspteridae is the ancestor of many angiosperms. Campbell (1930) believed that angiosperm might have been evolved from pteridophytes due to their similarity with eusporangiate ferns and monocotyledons have been evolved from Isoetes as far as the position of embryo sac, mode of lateral growth and formation of stem apex as in *Alisma* & Isoetes although it was rejected by the group of phylogenists.

## DIFFERENT THEORIES TO EXPLORE THE REALITY

- ▶ **1. Pteridosperm theory:** On the basis of histology and stellar structure (Andrew, 1947; Arnold, 1949; Cronquist, 1968)), seed ferns are thought to be ancestor of angiosperms. In both the cases, eusporangiate type development, two traces to one gap and amphiphloic stele, they share some common characters and the laminar type of placentation is somehow related to the soral distribution of the ferns. But the simple structure of angiosperm ovule and complex seed of pteridophytes are points of disagreement.
- ▶ **2. Anthrostrombilus theory:** Angiosperm flower evolved from an unbranched bisexual strobilus bearing spirally arranged pollen and ovulate organs. It got similarity with the reproductive structure of ancient Bennettitalean gymnosperms. Bisexual; flowers of Magnoliales seems to have evolved from such stock. Bennettialean origin along with seed bearing organs, Caytonia and leaf structure of cycas show a degree of similarity in this regard.

# DIFFERENT THEORIES TO EXPLORE THE REALITY

- ▶ **3. Pseudanthial Theory:** Angiosperms took origin from Gnetopsida as proposed by Wettstein (1907) from the stocks like *Ephedra*, *Gnetum* and *Welwitschia* due to the following resemblances-
  - ▶ Reticulate dicot -like leaves in *Gnetum*,
  - ▶ Presence of vessels,
  - ▶ Male flower with perianth and bract,
  - ▶ Reduction in male gametophyte with ventral canal nucleus,
  - ▶ *Ephedra* shows *Casuarinas* like habit
- ▶ Homology between compound strobilus of Gentales with the inflorescence of wind pollinated Amentiferae along with insect pollinated bisexual flowers of *Magnolia* . This theory was not supported by Carlquist (1996), Young (1981) and others. But Cornet (1996) discovered *Welwitschia* like fossils *Archaeostrobus cupularanthus* and this strengthen the Gnetopsida origin of angiosperms. The male and female spikes of fossil plant possess many spirally arranged microcupules. Each macrocupule carried an ovule surrounded by sterile scales. With these features, Gnetopsida considered to be close member of angiosperms.

## DIFFERENT THEORIES TO EXPLORE THE REALITY

- ▶ **4. Anthocorm Theory:** It is based on polyphyletic origin of angiosperms proposed by Niemeyer (1924). As far as this theory, the angiosperm flower has several separate origin. In Magnoliidae and their derivatives, they are modified pluriaxial system i.e. holoanthocorms which are thought to be derived from gnetopsida via the piperales. But the original modified uniaxial system i.e. gonocladus or anthroid gave rise to the flower of Chloranthaceae. Meeuse (1963) advocated for the origin of monocotyledons from the fossil order Pentoxiales through monocot order of Pandanales. The Pentoxiales were woody plants and their stem had many conducting strands each with its cambium. The feature gives a clue for the link with the many monocotyledons due to their many vascular bundles in the stem. The leaf genus Of Pentoxylon known as Pentophyllum that are star shaped and had a dominant midrib with parallel venation. The pollen bearing organs. Sahanias were similar to the Bennettiales. The seed bearing structure was similar to Mulberry and the outer fleshy sarcotesta was considered homologous to the cupule of the seed ferns. Taylor and Hickey (1996) excluded Pentoxylon from Anthophytes through the latter contains angiosperm lineage and its sister groups Benenettiales and Genetopsida.

# DIFFERENT THEORIES TO EXPLORE THE REALITY

- ▶ **5. Gonophyll Theory:** this theory was put forwarded by Melville (1962, 63, 83) on the basis of the angiosperm was a leaf with an epiphyllous fertile branch known as gonophyll. According to him, angiosperm arose 240mya in the Permian and took around 140mya before they widely spread in the cretaceous. In simple glossopteris scutum and Ottokoria, the fertile branch contained a bivalve scale having two wings called scutella. The latter carried terminal ovules on dichotomous groups of branches. Folding of the scutella along the cluster of ovules forms the angiosperm condition. The closure condition was found in the Permian fossil Breytenia. The fertile branch of Lidgettonia carries 4-8 disc-like bearing several seeds. A genus Denkania discovered from Raniganj, W.B. India bears 6 seed bearing cupules that are attached to the long stalks borne from the midrib of the fertile scale. The leaves of glossopteris are lanceolate with reticulate venation. The cone structure has spirally arranged fertile leaves and forms the anthostrobilus. The anthofasciculus i.e. leaves structure with two fertile branches, one sterile and other is reported in Mudgea. It is comparable with the angiosperm flowers like *Ranunculus* and *Acacia*.

# DIFFERENT THEORIES TO EXPLORE THE REALITY

- ▶ **7.Herbaceous origin Hypothesis:** The ancestral plants are thought to be considered as rhizomatous herbs not the trees. Donoghue and Doyle (1989) coined the term paleoherbs for a group of plant of Magnoliidae. They found to occur the features like anomocytic stomata, two whorls of perianth and trimerous flowers in the plants and it includes the families like Lactoridaceae, Aristolochiaceae, cobombaceae, Piperales, Nymphaceae & monocots. According to this hypothesis, the ancestral plants possess the following features-
  - ▶ Ancient angiosperm plants were perennial with rhizomatous to scrambling habit,
  - ▶ Leaves were simple, reticulate veined and dichotomous branching of secondary veins,
  - ▶ Sieve elements with treachery elements with both circular bordered and scalariform pitting with oblique end walls,
  - ▶ Flowers with racemose or cymose inflorescence,
  - ▶ Small monosulcate had perforate to reticulate sculpturing,

# DIFFERENT THEORIES TO EXPLORE THE REALITY

- ▶ Carpels free, ovules attached proximally to the closure. There are one to two orthotropous, bitegmic, crassinuculate ovule and the dicotyledonous embryo.
- ▶ The recent findings suggest that Gnepheids are the closest to the living relatives of the angiosperms and the closest fossil group of the Bennettiales. Anthophytes during the Late Jurassic divided into stem Angiophytes, the early angiosperms and crown Angiophytes constituting the extant group of angiosperms.
- ▶ A group of Proangiosperms Caytoniales, Zekkanowskiales and Dirhopalostachyaceae was identified by Krassilov in the Jurassic. He argued to consider these plants as angiosperm instead of researching their ancestors. He further traced Laurales-Rosales series from Caytoniales. Zekkanowskiales possessed bivalve capsules having stigmatic bands that showed links with monocots. Dirhopalostachyaceae probably evolved in Hamamelidales due to paired ovules exposed on shield-like lateral appendages.

# DIFFERENT THEORIES TO EXPLORE THE REALITY

- ▶ 6. Transitional-Combinational Theory: J. Stuessy (2004) put forth this theory as far as the origin of angiosperm is concerned. The angiosperms evolved gradually and slowly from seed ferns in the Jurassic. He considers that Carpels, double fertilization and the flowers to evolve one after another. These three fundamental transitions might have taken more than 100 mya to complete the process. The fossil record confirmed that the living angiosperm did not come up until Early cretaceous when the final combination of these three important angiosperm features took place . The theory attempts to remove discrepancy between fossil and molecular phylogenetic data. The latter gives indication of Pre-cretaceous origin of angiosperm. But DNA sequences showed first change was in carpel evolution. The event is much earlier than the final combination of all the three angiosperm features. This theory give emphasis on the origin of angiosperm from seed ferns and no other gymnosperms had direct phylogenetic link to modern angiosperm.
- ▶ It is accepted that the early angiosperms were small trees or woody shrubs with simple evergreen entire and pinnately veined leaves having stipule. Further it is believed that primitive angiosperms evolved in very late Jurassic period. There are

# DIFFERENT THEORIES TO EXPLORE THE REALITY

- ▶ Two schools of thought regarding the origin of angiosperms.
- ▶ The Englerian school considers Casuarinaceae as the most primitive among dicots whereas Bessey school thinks bisexual flowers of Magnoliales to be the most primitive. During the last few years, paleoherbs provide the essential clue on primitive angiosperm.
- ▶ The primary basal groups were chosen as primitive include Casuarinaceae, Magnoliaceae, Winteraceae, Degeneriaceae and Calcanthaceae. APG II considered Magnoliidae and Nymphaeidae as the true basal group instead of Degeneriaceae and Placed Amborellaceae at the beginning.
- ▶ At the end of the 20<sup>th</sup> century, the herbaceous origin of angiosperms has been gaining much more emphasis in this regard.
- ▶ As far as the origin of monocots, different theories have been put forward by the number of scientists as stated below:
- ▶ Bailey (1944) & Cheadle (1953) gave emphasis on origin of vessels and they concluded vessels had independent origin and special in monocots and dicots.
- ▶ Cronquist ( 1968) did not agree with the independent origin of vessel in two groups.

# ORIGIN OF MONOCOTS

- ▶ He believed in aquatic origin of monocots that resemble with Nymphaeales.
- ▶ Kjosakai , Mosely and Cheadle (1970) did not accept the view of Cronquist. Advance vessels are observed in Alismatiaceae in an aquatic environment and the terrestrial monocots evolved with ancient vessels elements in the metaxylem of roots.
- ▶ Monocotyledons evolved in two lines- One from Ranunculoideae giving rise to Alismatiales and another from heleboroideae giving rise to Butamales as per Hutchinson (1973).
- ▶ Takhtajan (1980, 1987) believed in a common origin of Nymphaeales and Alismatiales from hypothetical terrestrial herbaceous group of Magnoiliidae.
- ▶ Dahlgren et al. (1985) described that monocots evolved 110 mya ago during Early cretaceous.
- ▶ Chase et al. (1993) observed the monophyletic origin of and from within monosulcate pollen of Magonliidae.

# THANKS FOR YOUR HECTIC JOURNEY

- ▶ References:
- ▶ 1. Google for images
- ▶ Different websites for content,
- ▶ Plant taxonomy- O.P.Sharma
- ▶ Text Book of Plant Systematics- Chittaranjan Mohanty,
- ▶ A Textbook of botany- Hait, Bhattacharyya & Ghosh
- ▶ Advanced Plant taxonomy- A.K. Mondal
- ▶ *Disclaimer: This PPT has been prepared to enrich open source of knowledge for the academic fraternity without any financial interest.*